SPiRiT and SDD Training Course

SPiRiT Energy and Atmosphere

Building Energy Use

- Buildings in the US consume over 30% of the total energy load and about 60% of the electrical energy.
- Today’s emphasis is on efficiency and high performance space not on doing without.
- New efficiency means optimizing the building’s components individually, then in interaction with each other, taking advantage of synergies.

Energy Efficiency

- Energy efficiency means getting more in columns A and B below for less in column C.

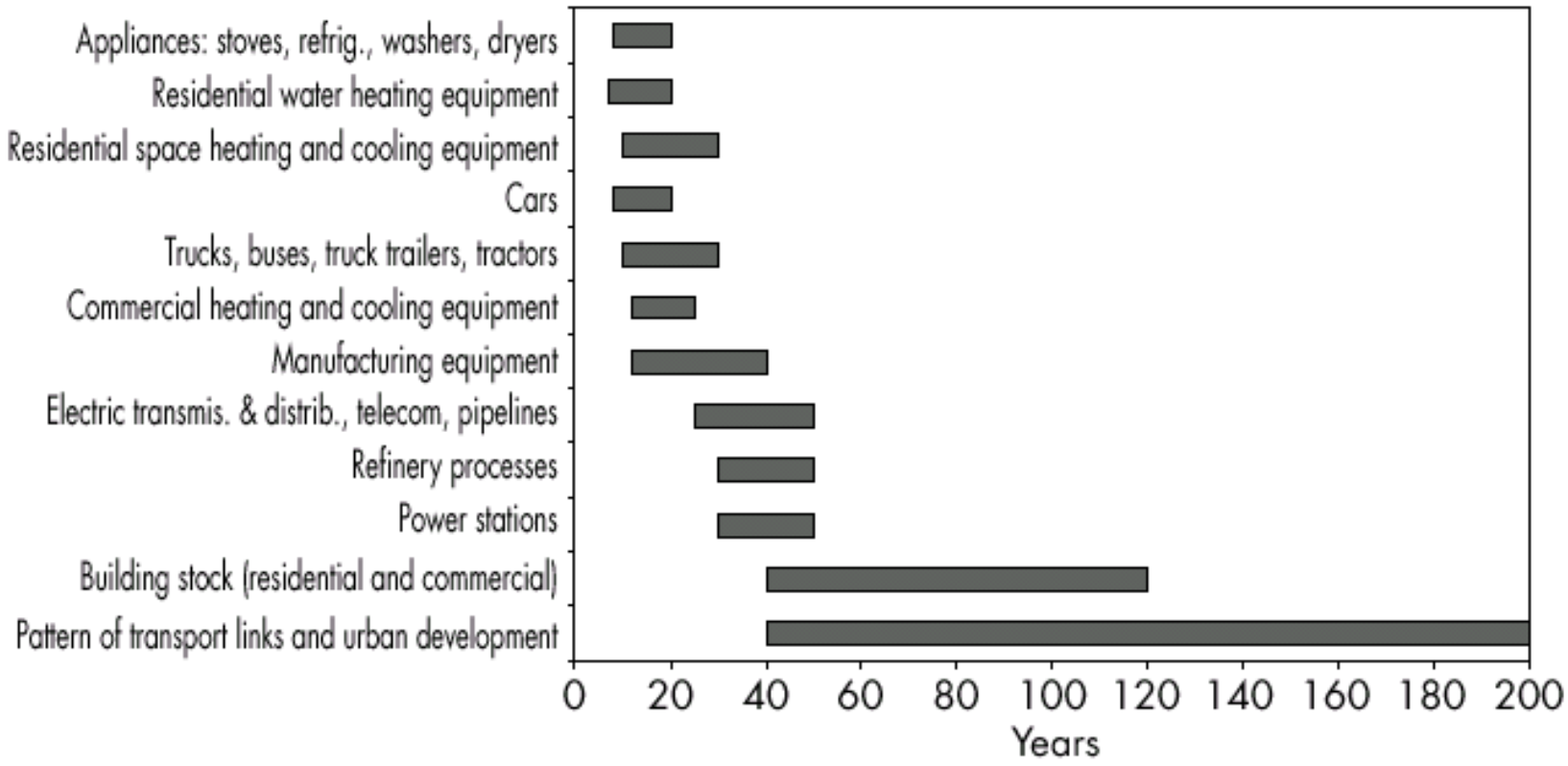
A	B	C
Heating	Productivity	Money
Cooling	Affordability	Pollution
Lighting	Performance	Energy
Comfort	Jobs	Hassle
Quality	Control	Waste

Efficient Buildings

- 27 quads are current savings in US.
- A large potential still exists to be capitalized in both existing and new buildings.
- New IPCC report finds that energy efficiency for buildings, transportation, and industry could account for more than half of the potential greenhouse gas reductions achievable by 2020.
- Energy efficiency expands the economy, creates jobs, saves consumers money, increases comfort, bolsters national security, and protects the environment.
- Increases in energy costs will make efficiency even more affordable and effective.

Our Decisions Today Endure

Average Lifetimes for Energy-related Capital Stock



Note: IEA (2000), World Energy Outlook 2000, p. 43.

A Whole-Building Approach to Design

Examines how a building interacts with its systems, activities, and surrounding environment. By optimizing the building's standard components - site, windows, walls, floors, and mechanical systems - building owners can substantially reduce energy use without increasing construction costs.

A Whole-Building Approach to Design

- The formation of a design team with a strong commitment to saving energy.
  - building owners
  - designers
  - builders
  - operators

For the design to be successful, the team must work together, using the whole-building approach from the start of the project - conceptual design phase - through the building's commissioning and operation.

SPiRiT – Energy and Atmosphere

- 3 Prerequisites – commissioning, energy performance, & CFCs
- 6 Credits for a total of 28 points:
  - Optimize energy performance
  - Renewable energy
  - Additional commissioning
  - M&V
  - Green Power
  - Distributed Generation

Energy and Atmosphere
Prerequisite 1 – Fundamental Building Systems Commissioning

INTENT:

- Verify and ensure that fundamental building elements and systems are designed, installed and calibrated to operate as intended.

Energy and Atmosphere
Prerequisite 1 – Fundamental Building Systems Commissioning

REQUIREMENT:

- Implement all of the following fundamental best practice commissioning procedures.
  - Engage a commissioning authority.
  - Develop design intent and basis of design documentation.
  - Include commissioning requirements in the construction documents.
  - Develop and utilize a commissioning plan.
  - Verify installation, functional performance, training and documentation.
  - Complete a commissioning report.

Energy and Atmosphere
Prerequisite 1 – Fundamental Building Systems Commissioning

TECHNOLOGIES/STRATEGIES:

- Introduce standards and strategies into the design process early, and then carry through selected measures by clearly stating target requirements in the construction documents. Tie contractor final payments to documented system performance. Refer to the LEED Reference Guide or the Corps Commission*pedia* for detailed descriptions of required elements and references to additional commissioning guides.

Commissioning Report

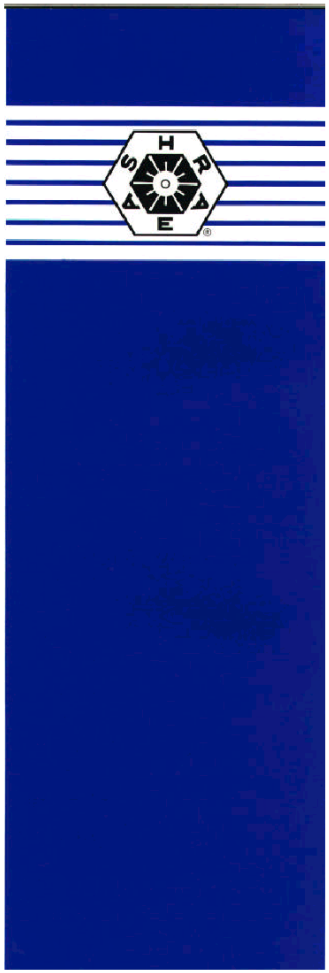
- Include the commissioning plan highlighting the six fundamental commissioning procedures listed in the requirements.
- Letter certifying that the commissioning plan has been successfully executed and design intents achieved.
- Commission agent can be in the firm, but not on the project team, per se.
- Traditional testing, adjusting, and balancing (TAB) is considered a “feature” to be verified through sampling during commissioning process.

Commissioning

- Introduce standards and strategies early in the design process and follow-through.
- New buildings: all HVAC systems and controls, duct work and pipe insulation, renewable and alternative energy technologies, lighting controls and daylighting systems, waste heat recovery, and advanced technologies such as thermal storage.

ASHRAE on Commissioning

- The Guideline presents details on the Commissioning Process without focusing on specific systems or assemblies.
- Supplementary technical guidelines are being developed to provide specific and detailed information on how to implement the Commissioning Process for each major system or assembly related to buildings and facilities.



ASHRAE Guideline 0P

ASHRAE®
GUIDELINE

The Commissioning Process

FIRST PUBLIC REVIEW
AUGUST 2002

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This draft has been recommended for public review by the responsible project committee. Public review of this proposed guideline has been authorized by a subcommittee of the Standards Committee. Instructions and a form for commenting are provided with this draft. Although reproduction of drafts during the public review period is encouraged to promote additional comment, permission must be obtained to reproduce all or any part of this document from the ASHRAE Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. Phone: 404-636-8400, Ext. 502. Fax: 404-321-5478. E-mail: cramspeck@ashrae.org.

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NOTICE
ASHRAE publishes Guidelines in order to provide assistance to interested parties on issues which relate to the design, testing, application and/or evaluation of products, concepts and practices where there may be more than one acceptable approach. Guidelines are not mandatory and only provide one source of information that may be helpful in any given situation.

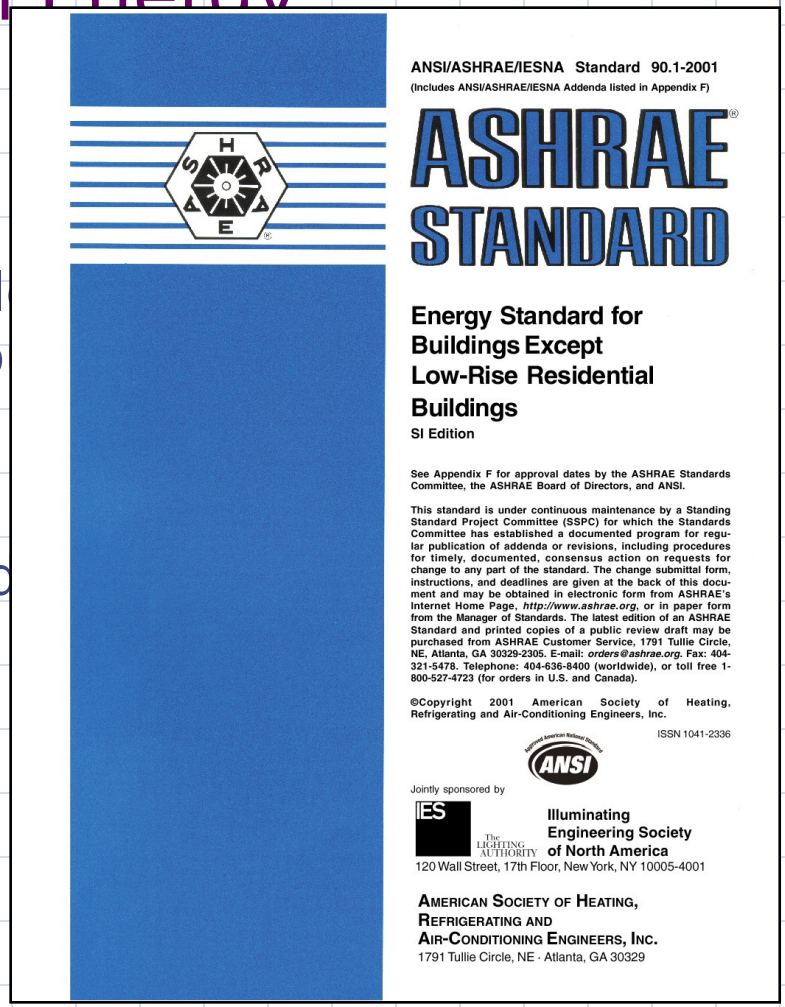
Energy and Atmosphere
Prerequisite 2 – Minimum Energy Performance

INTENT:

- Establish the minimum l
  efficiency for the base b

REQUIREMENT:

- Design to meet building
  performance as required
  Criteria).


ANSI/ASHRAE/IESNA Standard 90.1-2001
(Includes ANSI/ASHRAE/IESNA Addenda listed in Appendix F)

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

SI Edition

See Appendix F for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and ANSI.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines are given at the back of this document and may be obtained in electronic form from ASHRAE's Internet Home Page, *http://www.ashrae.org*, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard and printed copies of a public review draft may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: *orders@ashrae.org*. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in U.S. and Canada).

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ANSI

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IES The Lighting Authority

Illuminating Engineering Society of North America
120 Wall Street, 17th Floor, New York, NY 10005-4001

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ASHRAE Std 90-2001 is now the new standard for Army Buildings (UFC 3-400-1, adopted 28 Oct 02)

Energy and Atmosphere
Prerequisite 2 – Minimum Energy Performance

TECHNOLOGIES/STRATEGIES:

- Use building modeling and analysis techniques to establish and document compliance.
- TI 800-01 and ASHRAE/IESNA 90.1-2001 provide guidance for establishing building base case development and analysis.
- Refer to the LEED Reference Guide for a wide variety of energy efficiency strategy resources.

ASHRAE Standard 90

- Mandatory Provisions:
  - Building envelope (insulation installation, air leakage, prescriptive option, trade-off option).
  - HVAC (equipment efficiency, load calcs, controls, duct and piping insulation and leakage, drawing, manual, balancing, prescriptive path).
  - Service water heating (similar to HVAC rqmts).
  - Power (max voltage drop 2% in feeders and 3% in branch circuits).
  - Lighting (controls, tandem wiring, exit signs, lighting power, exterior lighting, prescriptive path).
  - Other equipment (motors).

Energy and Atmosphere

Prerequisite 3 – CFC Reduction in HVAC&R Equipment

INTENT:

- Reduce ozone depletion.

REQUIREMENT:

- Zero use of CFC-based refrigerants in new base building building HVAC&R systems. When reusing existing base building HVAC equipment, complete a comprehensive CFC phase out conversion.

TECHNOLOGIES/STRATEGIES:

- Specify only non-CFC-based refrigerants in all base building HVAC&R systems.

Energy and Atmosphere
Credit 1 – Optimize Energy Performance

INTENT:

Achieve increasing levels of energy performance above the prerequisite standard to reduce environmental impacts associated with excessive energy use.

REQUIREMENT:

Reduce design energy usage (DEU) compared to the energy use budget (EUB) Use the Energy Cost Budget Method to evaluate energy reductions for regulated energy components described in the requirements of Chapter 11 of the TI 800-1 (Design Criteria), as demonstrated by a whole building simulation (1-20 points).

Energy and Atmosphere
Credit 1 – Optimize Energy Performance

1 Point awarded for every reduction in design energy use Energy Cost Budget of 2.5% for both new and existing facilities for a maximum score of 20 points.

Regulated energy components include HVAC systems, building envelope, service hot water systems, lighting and other regulated systems as defined by ASHRAE.

Energy and Atmosphere
Credit 1 – Optimize Energy Performance
TECHNOLOGIES/STRATEGIES:

- Develop and use building modeling and analysis techniques to establish a base case that meets the minimum prerequisite standard.
- TI800-01 and ASHRAE/IESNA 90.1-2001 provide guidance for establishing building base case development and analysis.
- Perform interactive energy use analysis for selected design elements that affect energy performance and document compliance.
- Draft ASHRAE Std 90 Appendix G provides additional guidance on calculating performance savings.

Energy and Atmosphere
Credit 1 – Optimize Energy Performance

- Unit of measure for performance shall be annual energy ~~usage in joules per square meter~~ cost budget. Life-Cycle energy costs shall be determined using rates for purchased energy, such as electricity, gas, oil, propane, steam, and chilled water and approved by the adopting authority. Refer to the LEED Reference Guide or Whole Building Design Guide for a wide variety of energy efficiency resources and strategies including conservation measures, electromechanical energy efficiency technologies (for example ground-source heat pumps), passive heating and cooling strategies, solar hot water, and daylighting.

Nine-Step Process for Low-Energy Building Design

(1) Create a base case building model to quantify base case energy use and costs. The base case building is solar neutral (equal glazing areas on all wall orientations) and meets the requirements of applicable energy efficiency codes such as ASHRAE Standard 90.1 and 90.2.

Optimizing Building and HVAC Systems. Hayter, Torcellini, & Judkoff. ASHRAE Journal Dec 99, vol 41, no. 12.

Nine-Step Process for Low-Energy Building Design (cont)

(2) Complete a parametric analysis to determine sensitivities to specific load components. Sequentially eliminate loads from the base case building, such as conductive losses, lighting loads, solar gains, and plug loads.

(3) Develop preliminary design solutions. The design team brainstorms possible solutions that may include strategies to reduce lighting and cooling loads by incorporating daylighting or to meet heating loads with passive solar heating.

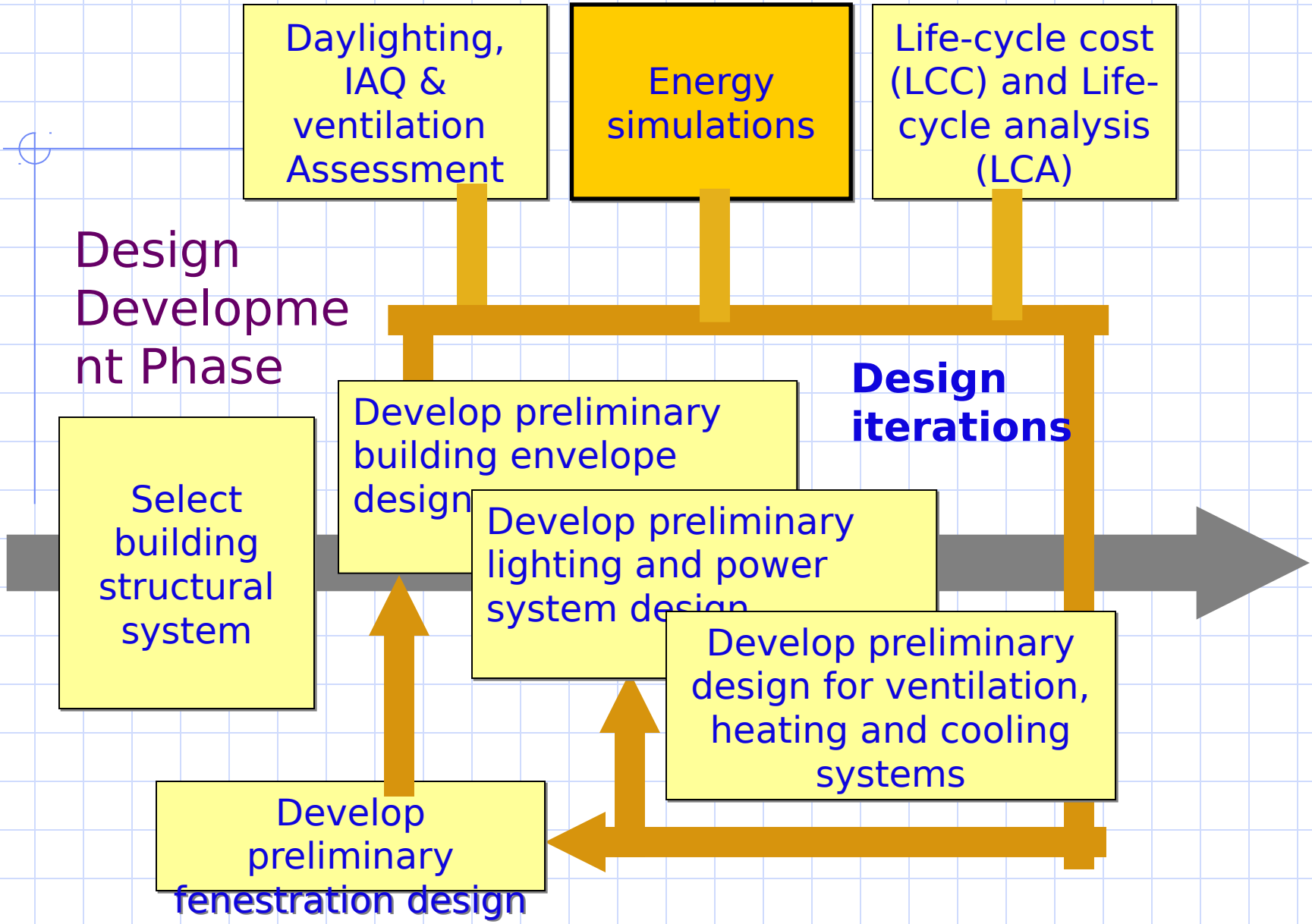
Nine-Step Process for Low-Energy Building Design (cont)

(4) Incorporate preliminary design solutions into a computer model of the proposed building design. Energy impact and cost effectiveness of each variant is determined by comparing the energy with the original base case building and to the other variants. Those variants having the most favorable results should be incorporated into the building design.

Nine-Step Process for Low-Energy Building Design (cont)

(5) Prepare preliminary set of construction drawings. These drawings are based on the decisions made in Step 4.

(6) Identify an HVAC system that will meet the predicted loads. The HVAC system should work with the building envelope and exploit the specific climatic characteristics of the site for maximum efficiency. Often, the HVAC system is smaller than in a typical building.


Daylighting, IAQ & ventilation Assessment
Energy simulations
Life-cycle cost (LCC) and Life-cycle analysis (LCA)
Design Development Phase
Design iterations
Develop preliminary building envelope design
Select building structural system
Develop preliminary lighting and power system design
Develop preliminary design for ventilation, heating and cooling systems
Develop preliminary fenestration design

Nine-Step Process for Low-Energy Building Design (cont)

(7) Finalize plans and specifications. Ensure the building plans are properly detailed and that the specifications are accurate. The final design simulation should incorporate all cost-effective features. Savings exceeding 50% from a base case building are frequently possible with this approach.

Nine-Step Process for Low-Energy Building Design (cont)

(8) Rerun simulations before design changes are made during construction. Verify that changes will not adversely affect the building's energy performance.

(9) Commission all equipment and controls. Educate building operators. A building that is not properly commissioned will not meet the energy efficiency design goals. Building operators must understand how to properly operate the building to maximize its performance.

Site and Massing Considerations

- Take advantage of the physical features of the site and microclimate
  - orient for optimum solar access
  - minimize impacts of prevailing winds
  - tree types and locations
  - topographic modifications

Dibble residence,
New Glarus, WI

Interior Layout/Spatial Design

- Program zoning - group similar functions together with same HVAC requirements
- Use non-windowed spaces as buffers
- Use circulation zones as buffers
- Layout for natural systems - configure spaces to use natural lighting & ventilation
- Stairs - pleasant staircases invite usage
- Existing natural systems - in retrofits preserve and enhance existing passive and energy efficient strategies

Building Envelope

- Everything that separates the interior of a building from the outdoor environment:
  - Windows
  - Walls
  - Foundation
  - basement slab
  - Ceiling
  - Roof
  - Insulation

Building Envelope

- Appropriate assembly of walls, roof, foundation, & windows provide good thermal and moisture control while supporting reductions in building loads
- A good envelope harnesses natural energy through effective use passive tempering and daylighting and also reduces system size and costs

Building Envelope (cont.)

- Passive solar - achieve low- or no-cost tempering and lighting
  - regulate solar impact through fenestration and shading devices
  - moderate interior temps with thermal mass - use building mass as flywheel
  - use insulation to reduce loads
  - ‘air-lock’ entrances to reduce infiltration
  - use light-colored, reflective roofing

Building Envelope (cont.)

- Natural Ventilation - consider integrating natural ventilation strategies in the design of HVAC and exterior wall openings
- Envelope detailing:
  - use best vapor barrier practices
  - use monolithic assemblies to minimize need for caulking
  - avoid thermal bridging

Building Envelope (cont.)

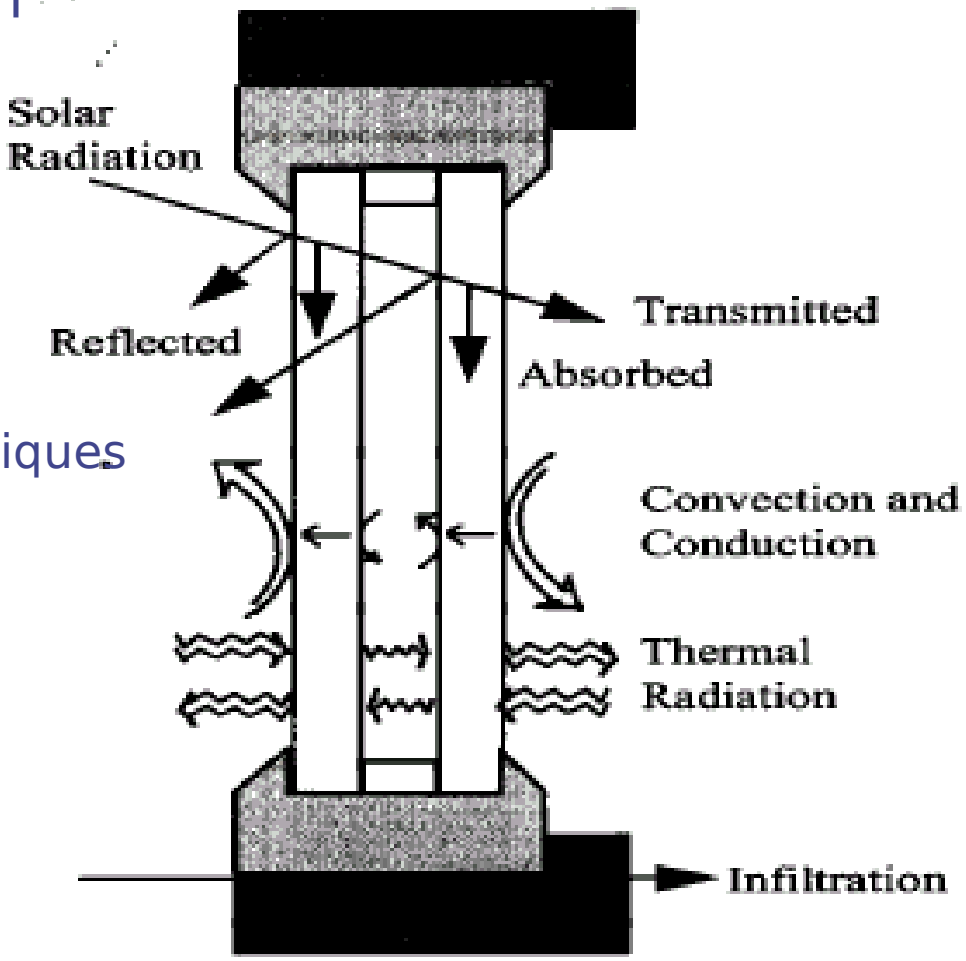
- Reduce unplanned air flows
  - reduce stack effect
  - seal between floors, stairwells, corridors, and elevator shafts
  - seal distribution plenums and ductwork
  - plan air pressure relationships between zones
- Radiant cooling - use envelope as heat sink for the interior heat loads

Daylighting/Sun Control

- Daylighting is the preferred mode of interior illumination
- Glazing:
  - specify high visible transmittance and integrate placement in envelope to control glare (windows must “see” and transmit the light of day)
  - consider translucent or spectrally selective glazing tuned to orientation
  - use high clerestories vice skylights

Fenestration and Glazing

- Basic historic function of a window is to introduce natural light and ventilation
- Technological innovation
  - advanced thermal glazing
    - low E coatings
    - optically sensitive
    - super insulated windows
  - gas fills and vacuums
  - improved glass coating
  - improved edge sealing techniques
  - suspended films
    - low SC and UV
    - high VT
  - improved window frames
    - reduce infiltration

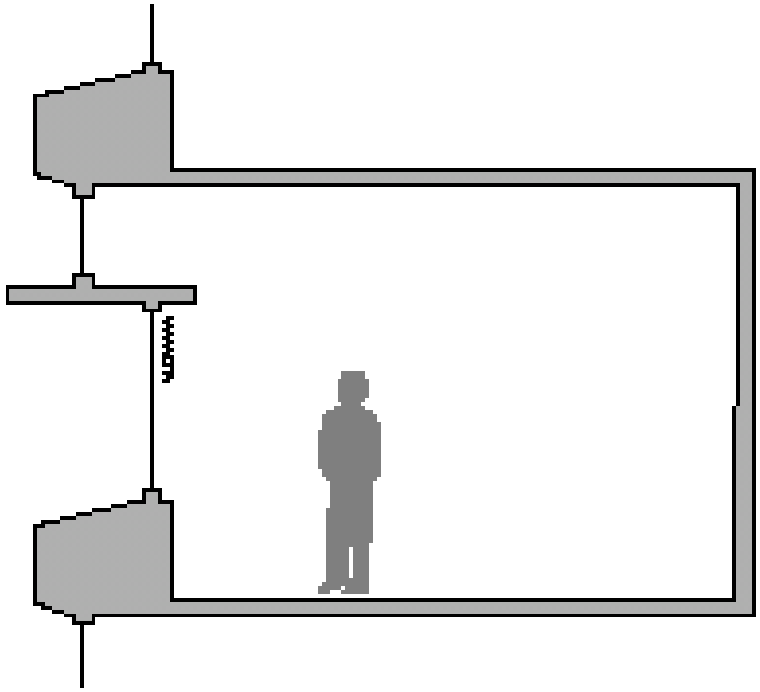


Daylighting/Sun Control (cont.)

- Daylight activated controls - adjust light level based on available natural light
- Design daylight for the task
- Assess daylight feasibility for each difference portion of the building
- Courtyards and atria - use to enhance daylight into the interior
- Fiber-optics - consider along with light-pipes to transmit natural light deep into interior spaces

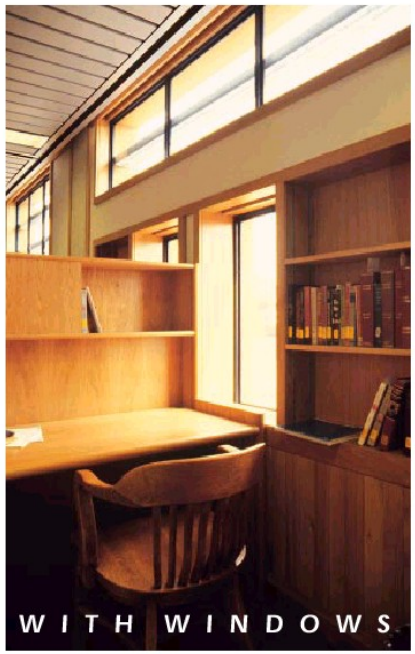
Daylighting/Sun Control (cont.)

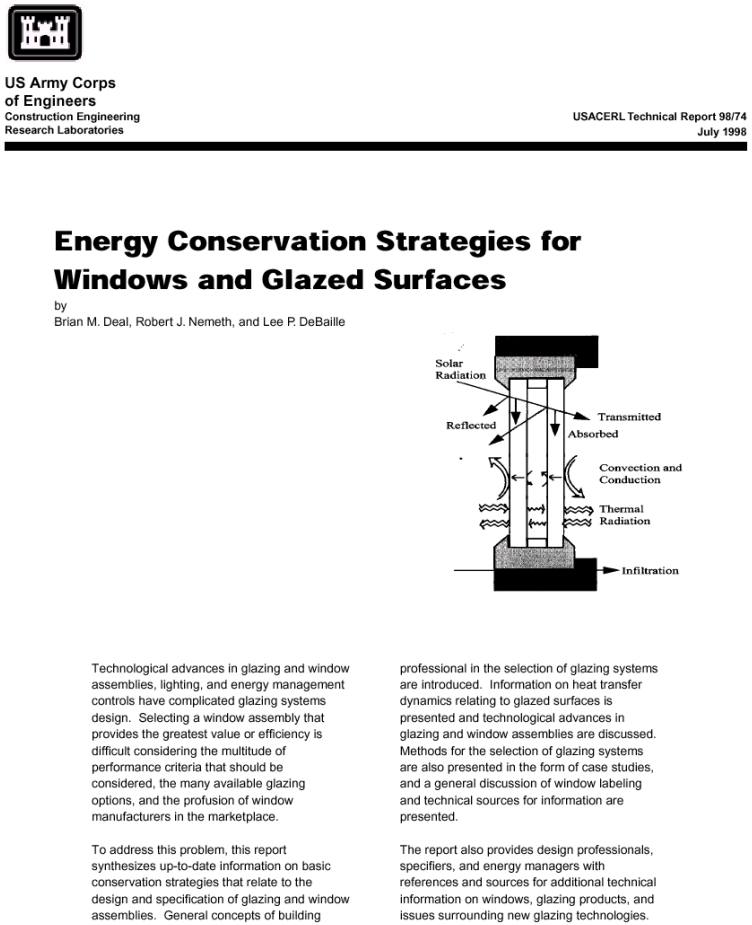
- Light shelves - reflect light deeper into space
  - consider use both interior and exterior on south-, east-, and west-facing facades
  - shape the building for self-shading - provide shading devices to control contrast and glare



Deep wall section provides self-shading, allows easy integration of light shelf, creates surfaces that mitigate glare, and reduces noise transmission. Sloped surfaces also help soften glare.

Resources


TIPS FOR DAYLIGHTING
WITH WINDOWS
The Integrated Approach
LBNL-39945
Ernest Orlando Lawrence Berkeley National Laboratory


US Army Corps
of Engineers
Construction Engineering
Research Laboratories
USACERL Technical Report 98/74
July 1998
Energy Conservation Strategies for
Windows and Glazed Surfaces
by
Brian M. Deal, Robert J. Nemeth, and Lee P. DeBaille
Solar
Radiation
Reflected
Transmitted
Absorbed
Convection and
Conduction
Thermal
Radiation
Infiltration
Technological advances in glazing and window assemblies, lighting, and energy management controls have complicated glazing systems design. Selecting a window assembly that provides the greatest value or efficiency is difficult considering the multitude of performance criteria that should be considered, the many available glazing options, and the profusion of window manufacturers in the marketplace.
To address this problem, this report synthesizes up-to-date information on basic conservation strategies that relate to the design and specification of glazing and window assemblies. General concepts of building fenestration design and the role of the design professional in the selection of glazing systems are introduced. Information on heat transfer dynamics relating to glazed surfaces is presented and technological advances in glazing and window assemblies are discussed. Methods for the selection of glazing systems are also presented in the form of case studies, and a general discussion of window labeling and technical sources for information are presented.
The report also provides design professionals, specifiers, and energy managers with references and sources for additional technical information on windows, glazing products, and issues surrounding new glazing technologies.
Approved for public release; distribution is unlimited.

Daylighting optimization

Modifying the process to accommodate early feedback loops can provide great benefits

- Effect of reduced lighting load:
  - reduced lighting energy consumption
  - reduced peak electrical demand from smaller system
  - reduced cooling load on mechanical system
  - a possible increased cooling load from daylighting fenestration
  - a net cooling load reduction can be achieved through the use of spectrally selective windows

Daylighting optimization (cont)

- Mechanical implications from optimizing glazed surfaces
  - smaller chiller plant and reduced run-time
  - smaller cooling tower and distribution system
  - smaller heating plant and reduced run-time
  - smaller mechanical room requirements
- Cost implications
  - increased design costs
  - reduced utility costs (energy & demand) - lighting & HVAC
  - reduced capital cost of HVAC equipment
  - possible increase in the capital cost of lighting system

High Performance Lighting

- Lighting power density:
  - use efficient distribution
  - use low ambient levels with task lighting
  - wash walls and use pendant fixtures
  - use high efficiency lamps and luminaires with electronic ballasts
  - use good control - occupancy sensors, dimmers, photo cells, and time clocks
  - use lumen maintenance controls

High Performance Lighting

- Fixture uniformity - use group relamping and group cleaning
- Use latest technology
  - lighting is a moving target
  - new products continually come out
- Budget for about .5 watt/SF for general lighting

Electrical Systems and Equipment

- In large buildings consider higher voltages
- Specify Energy Star™ equipment
- Reduce distortion with harmonic filters
- Consider power factor correction
- Use premium efficiency motors (sized correctly)
- Consider DC when using renewables

Energized Systems

- Pumping Systems
  - Large pipes, small pumps, straight runs, minimum turns (well plan layout).
  - Use two-way valves and a primary-only pumping system with variable flow through the chillers and boilers.
- Air-side Systems
  - Large ducts, small fans, low pressure drops, low face velocities, rigid ducting.
  - VAV with reheat, digital control, supply reset and ventilation control, & raised floor distribution.

Energized Systems (cont.)

- Efficient motors w/variable speed drives
- High efficiency chillers & cooling towers (consider free cooling).

Selecting Chillers Efficiency Recommendations

Compressor Type and Capacity	Full-load kW/ton	IPLV kW/ton
Centrifugal 150-299 tons	0.59 or less	0.52 or less
Rotary Screw > 150 tons	0.64 or less	0.49 or less
Scroll 30-60 tons	1.23 or less	0.86 or less
Reciprocating 30-150 tons	1.23 or less	0.90 or less
Screw 70-200 tons	1.23 or less	0.98 or less

Selecting Chillers

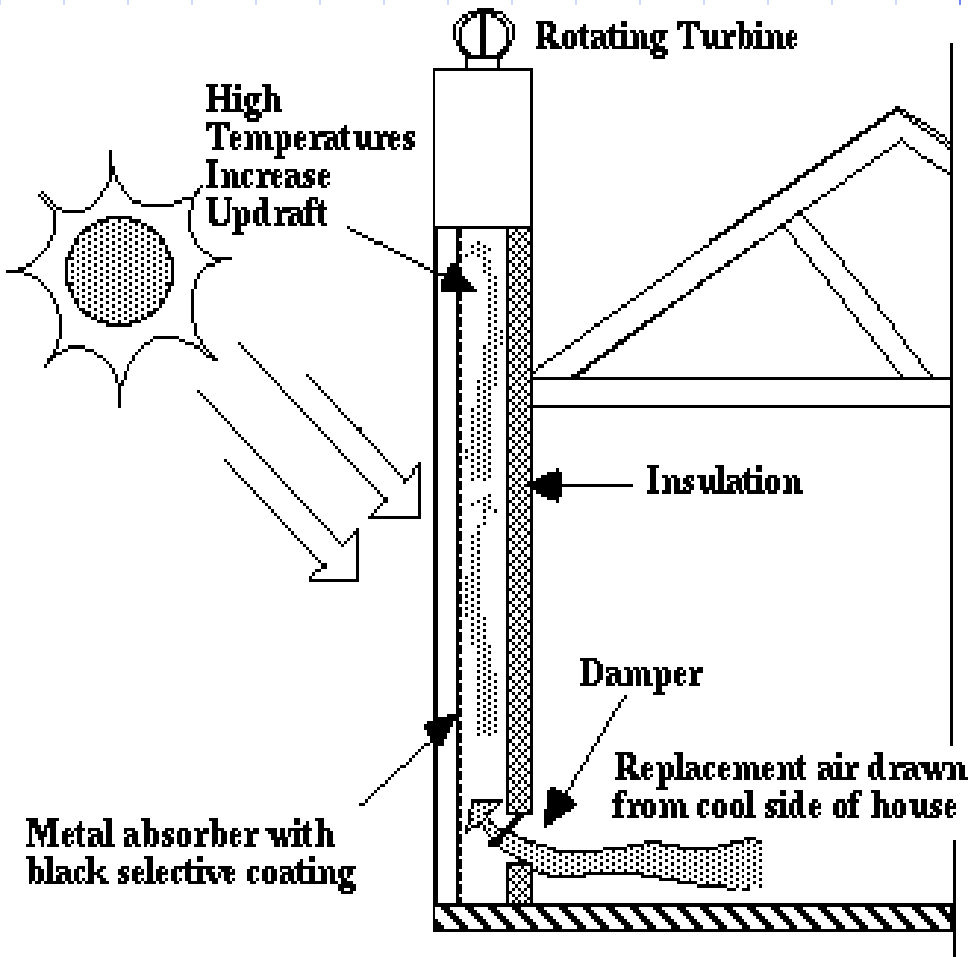
- Chillers with cooling towers are about twice as efficient as air cooled units
- Based on the load profile select for either part load efficiency or full load efficiency
- Make decisions on life cycle costs

Mechanical Systems

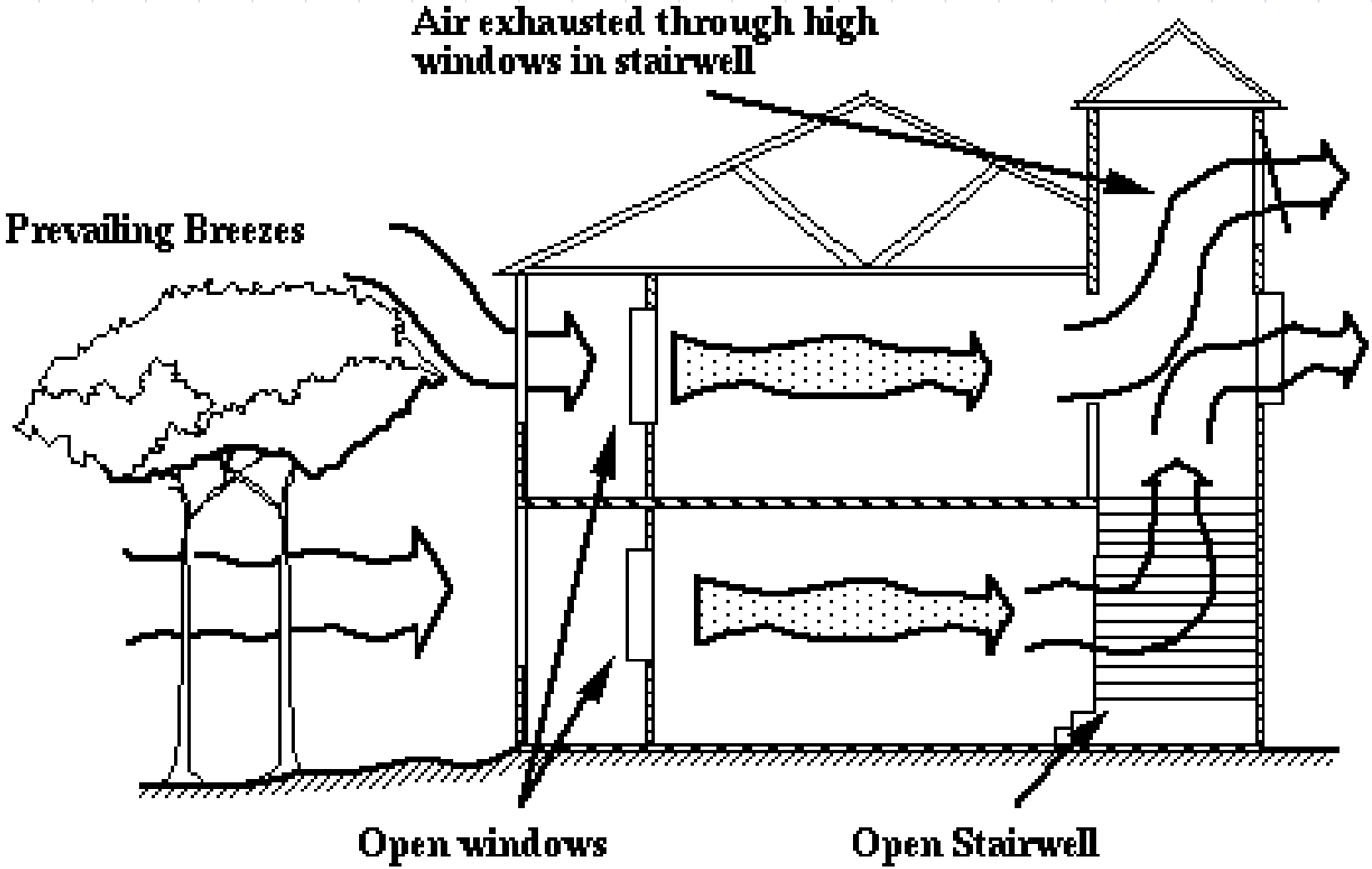
- Performance improvement - consider all aspects of energy usage to include conversion efficiencies at source
- Systems integration - selecting and sizing systems should be integrated with other building characteristics
- Zoning - use separate systems to serve widely disparate zones

Mechanical Systems (cont.)

- Natural ventilation - when practical, plan for natural ventilation (consider noise and air pollution)
- Thermal chimneys
  - narrow
  - thermally isolated
  - good with atria and open stairwells



Passive Cooling and Ventilation



Mechanical Systems (cont.)

- Mechanical rooms - consider dedicated mechanical room for each floor.
- Humidity control considered crucial to high performance workspace, both for comfort and mold/mildew control.
- Distribution system – complex issue now-a-days:
  - Enhanced constant volume systems
  - Systems that separate sensible and latent load
  - Variable air volume systems

Enhanced CV Systems

- Consider *true* return-air bypass (which does not vary coil area)
  - Lower supply air dew point, with little or no reheat
  - Indirectly lower design dp RH (72% to 55%)
- Consider supply air reheat within Std 90.1 limits
  - Lower supply air dew point
  - Directly control space RH to set point (72% to 50%)

Separate Sensible/Latent Load

- Consider a split-path unit
  - A small, deep coil dehumidifies ventilation air
  - A large, shallow coil cools recirculated return air
  - Directly control space RH to set point
- Consider dedicated outdoor air system
  - Local sensible-only units control space sensible load
  - A 100% OA unit dries ventilation air
  - Directly control space RH to set point

Variable Air Volume

- Consider multiple CV units
  - Staged units provide lower supply airflow and dew point at part load
  - Indirectly control space RH
- Consider multiple-speed CV units
  - Multiple-speed fan lowers supply dew point at part load
  - Indirectly (or directly) control space RH
- Consider traditional VAV system
  - Deliver dry supply air at all loads, reheat locally
  - Indirectly control space RH

Nothing Is Simple

- Sometimes, yes
  - For some packaged systems, more OA raises space RH
  - But basic CV systems all dehumidify poorly at part load
- Sometimes, no
  - Design enhanced CV systems
  - Remove latent load with dedicated outdoor air systems
  - Supply low dew point air with VAV systems
- Pick the right system, ventilate properly and control properly.

Mechanical Systems (cont.)

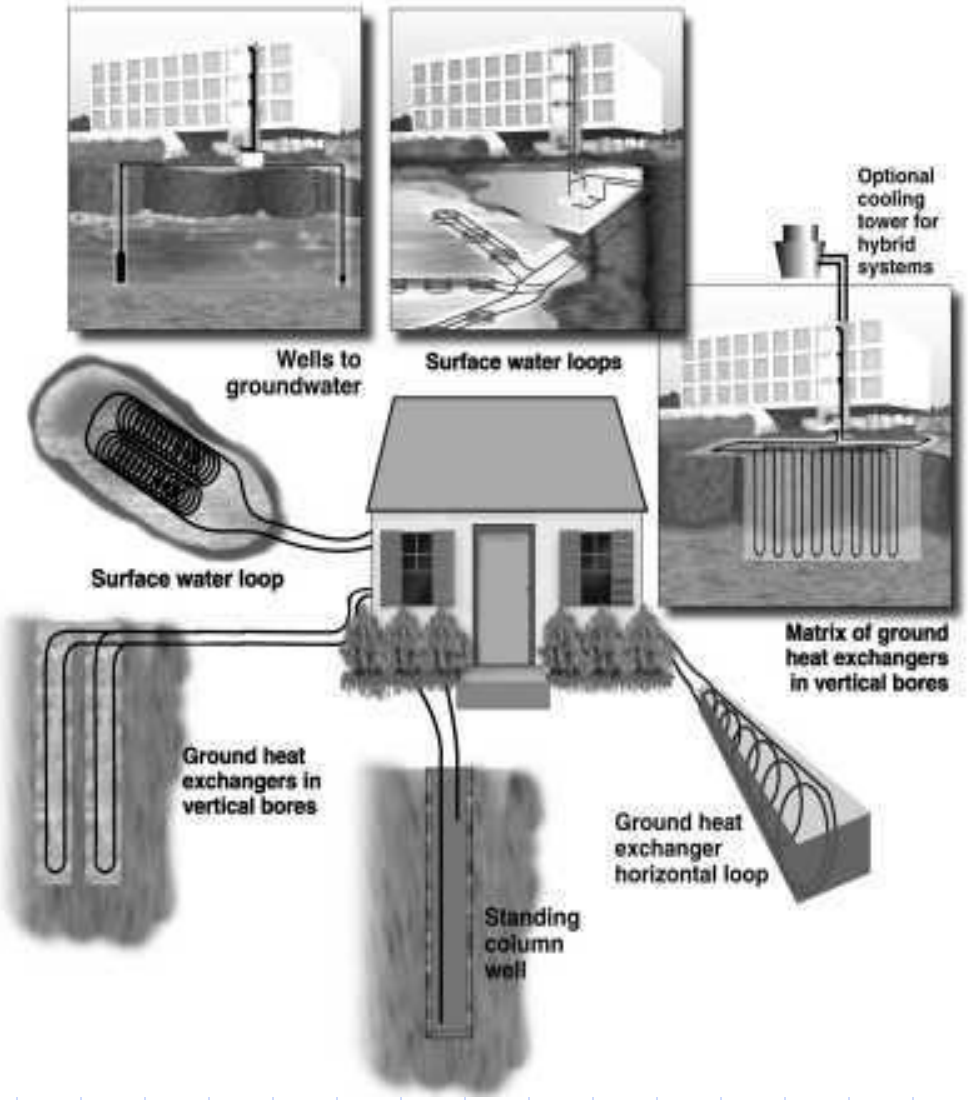
- Heat recovery - consider on large volume systems (4,000 cfm or greater)
- Modular boilers - better part load efficiency with dynamic sizing
- Chillers - select proper unit for load
- Thermal storage - ice or chilled water
- Desiccant - consider pre-cooling with desiccant unit

Geothermal Heat Pumps

- Wide applications: institutional (schools), convenience stores, health care, restaurants, hotels, offices
- Most notable Federal project: Ft. Polk with 4003 units eliminated NG, 33% reduction in electric use (7.5MW)
- Lower Maintenance: $0.11 to $0.16/SF (25 - 50% less)
- Higher 1st cost
- Some difficulty in using certain sinks/sources

Geothermal Heat Pumps

- Heating/Cooling
- Sources/Sinks
  - **Ground**
  - **Groundwater**
  - **Surface water**
  - **Waste water stream**
  - **Potable water**
- More stable source than air.


Optional cooling tower for hybrid systems
Wells to groundwater
Surface water loops
Surface water loop
Matrix of ground heat exchangers in vertical bores
Ground heat exchangers in vertical bores
Ground heat exchanger horizontal loop
Standing column well

Ventilation

- Ventilation
  - automatically controlled (CO_2), mechanical ventilation is essential for a tightly constructed structure
  - low-volume ventilation systems - circulate from 80 to 200 cubic feet of air per minute
- Increased fresh air requirements - ASHRAE 62

If makeup air is not supplied through a controlled system, it will be made up through leaks in the envelope. Water vapor contained in uncontrolled air leaking either way through the envelope can lead to internal decay.

Energy and Atmosphere
Credit 2 – Renewable Energy

INTENT: Encourage and recognize increasing levels of self-supply through renewable technologies to reduce environmental impacts associated with fossil fuel energy use.

REQUIREMENT: Supply a net fraction of the building's total energy use through the use of on-site renewable energy systems.

Total Energy Cost	Pts.
5%	1
10%	2
15%	3
20%	4

Energy and Atmosphere
Credit 2 – Renewable Energy

TECHNOLOGIES/STRATEGIES:

- Employ the use of on-site non-polluting-source renewable technologies contributing to the total energy requirements of the project. Consider and use high temperature solar and/or geothermal, wind, biomass (other than unsustainably harvested wood), and bio-gas.
  - Passive solar, solar hot water heating, ground-source heat pumps, and daylighting do not qualify for points under this credit. Credit for these strategies is given in Energy & Atmosphere Credit 1: Optimizing Energy Performance.

2000 World-wide Trends

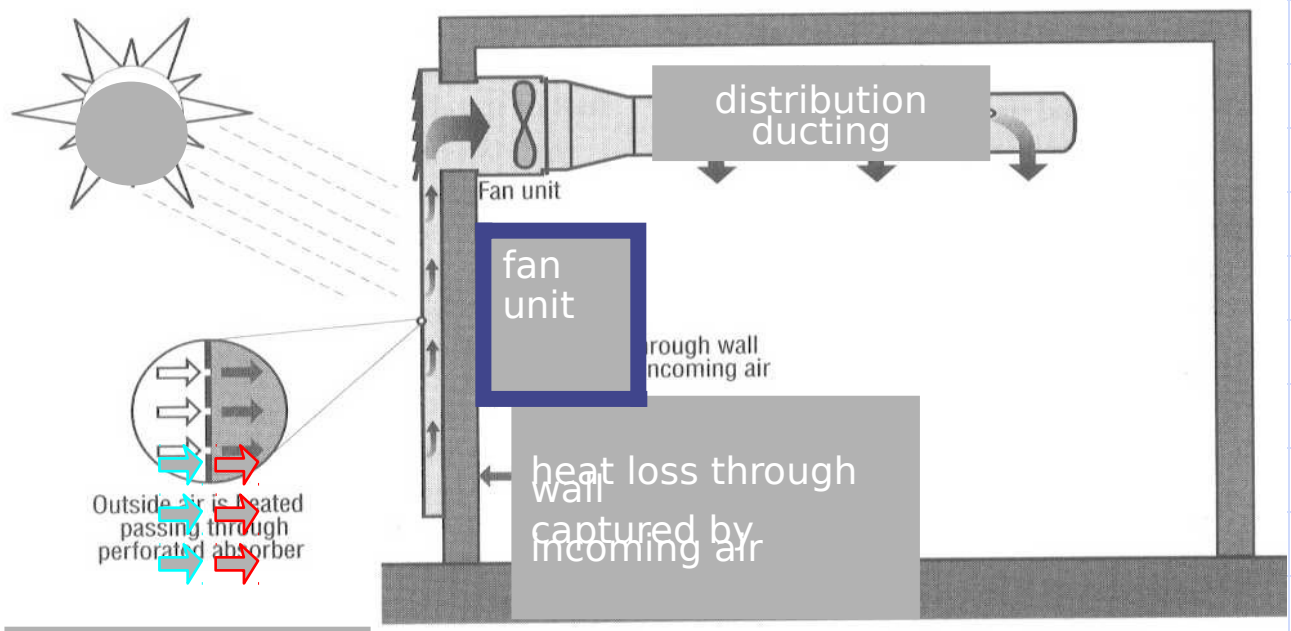
ENERGY SOURCE	ANNUAL RATE OF GROWTH (percent)
Wind power	+24.2
Solar photovoltaics	+17.3
Geothermal power	+4.3
Natural gas	+1.9
Hydroelectric power	+1.8
Oil	+0.8
Nuclear power	+0.5
Coal	-0.5

Compiled by Worldwatch Institute from: UN, DOE, BP, EC, Eurogas, PlanEcon, IMF, LBL, IAEA, EWEA, AWEA, FGW, Jose Santamarta, and Renewable Energy Report, Paul Maycock, and PV News.

Renewable Energy

- Hydropower has plateau - renewable electrical growth was from other renewable sources.
- Most hydro sites have been developed and new sites have significant opposition – some dams being taken down – clean but not green.

Transpired Collectors



- **Relatively long heating season.**
- **Large area, south-facing wall.**

Photovoltaics

Kwajalein Atoll

- Direct-coupled DC loads
- AC loads when the sun is shining
- AC or DC loads with battery storage
- Stand-alone isolated grid
- Hybrid systems

Fort Irwin

New Technology:

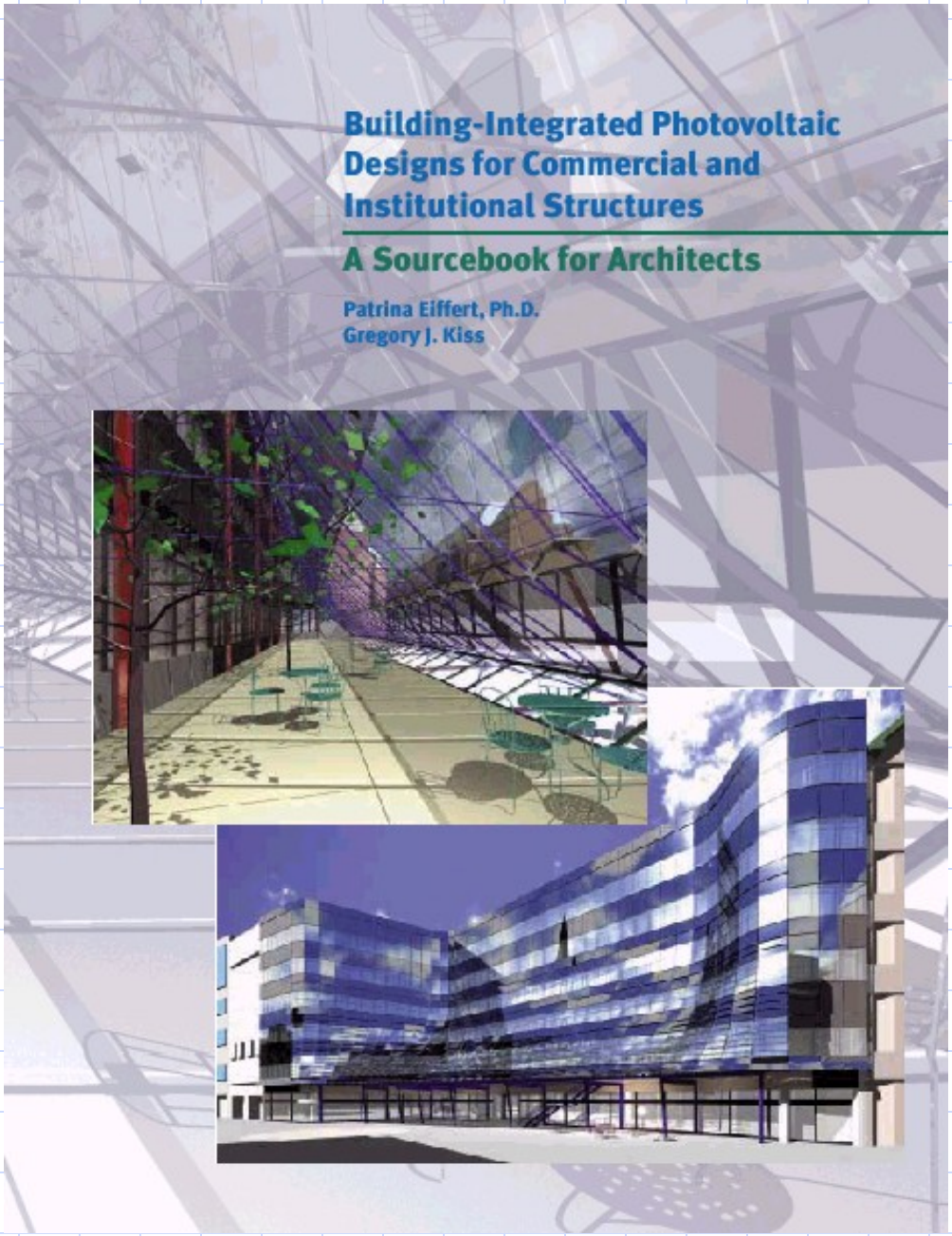
- 32.3 % efficient
- Double current ratings

Yuma Proving Ground

Photovoltaics

- In 1999, shipments were 77 peak megawatts - A 52% increase over 1998.
- Crystalline silicon cells and module dominate the market (96%).
- Average price decreased 26% from 1998 to $2.32 per cell.
- Average price for modules decreased 8% to $3.62/peak watt.

Building integrated photovoltaics


Building-Integrated Photovoltaic Designs for Commercial and Institutional Structures
A Sourcebook for Architects
Patrina Eiffert, Ph.D.
Gregory J. Kiss

Thin Film Solar PV

Rack Mounted Systems

Field Applied Systems

Standing Seam Metal Systems

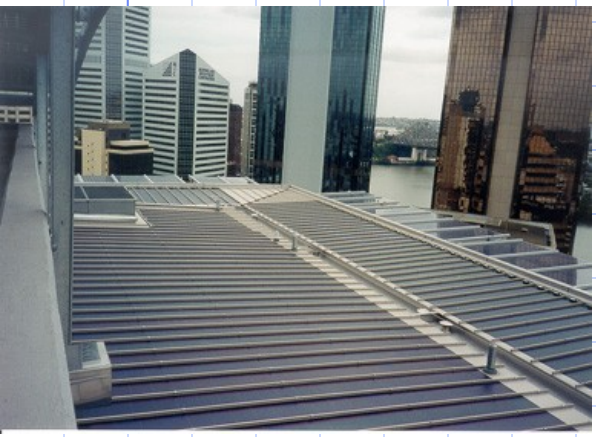
Shingle Systems

UNI-SOLAR® thin-film technology is available in a variety of styles. Rack-mounted. Standing seam. Even in shingle form. You don't have to compromise the aesthetics of your home to get the energy independence you want. The shingles and standing seam panels are true building-integrated, UL-Listed photovoltaic roofing products. And they're easy to install. You'll be up and running in less than a day.

http://www.uni-solar.com

Commercial Building Integrated Photovoltaics (BIPV)

Field Applied Roofing Laminate (PVL)



Brisbane, Australia
30 kW of *UNI-SOLAR*® PVL bonded on BHP Color Bond

Standing Seam Metal Systems (SSR)

Santa Monica, CA,
SolarPort generates 44,000kW/hours of electricity from the sun each year

Standard Rigid Module With Durable Frame

Roehamption-Vale, United Kingdom
10.5 kW system using rack-mounted US-64s

Wind Power

- Home-sized: rotors 8 to 25 ft dia, ~ 30 ft tall
- Largest utility: rotors > 300 ft dia, > 200 ft tall

Drawbacks:

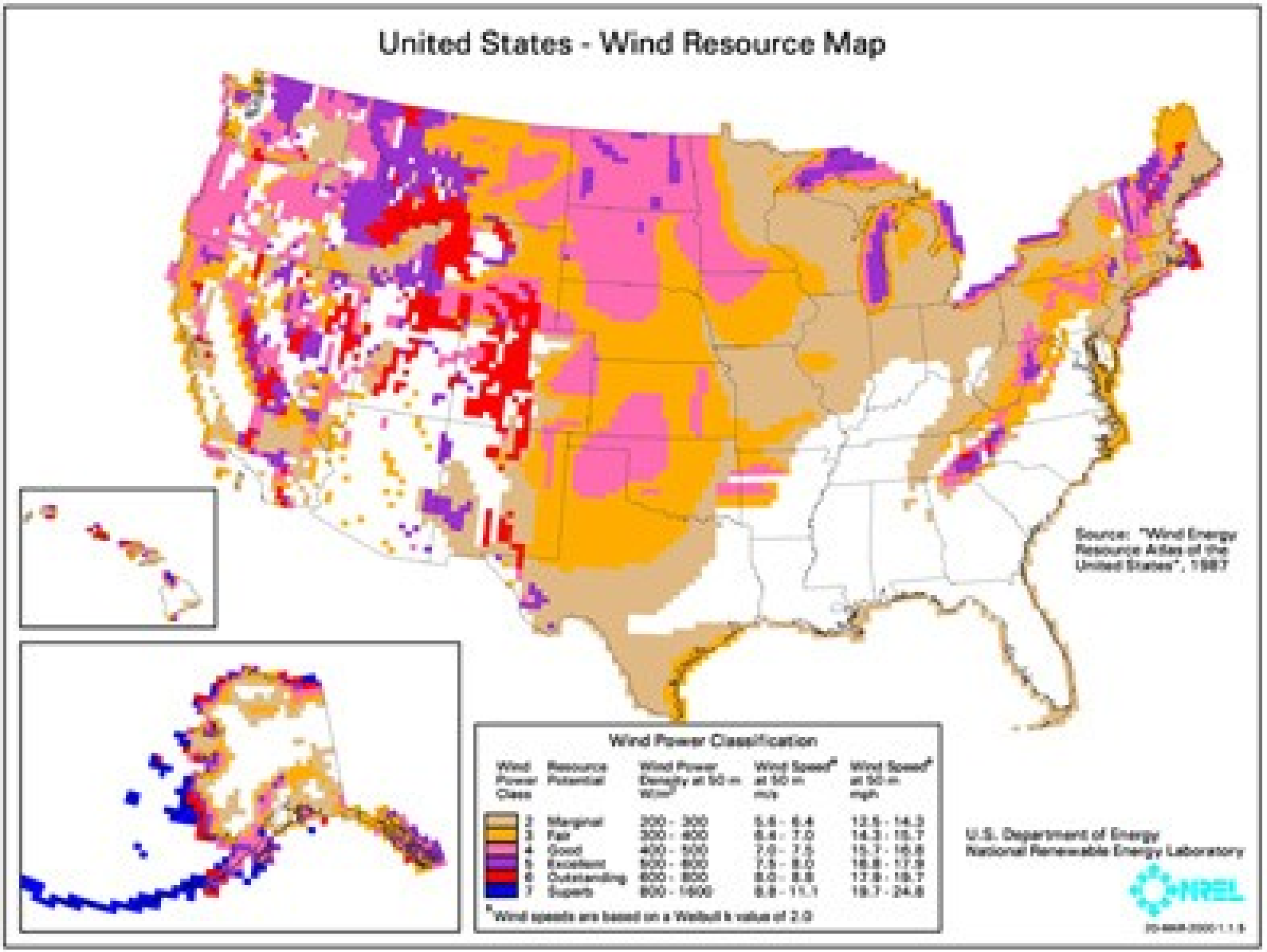
- Noise, aesthetics, bird kills
- Intermittent wind
- Good sites in remote locations
- Competition with other land uses

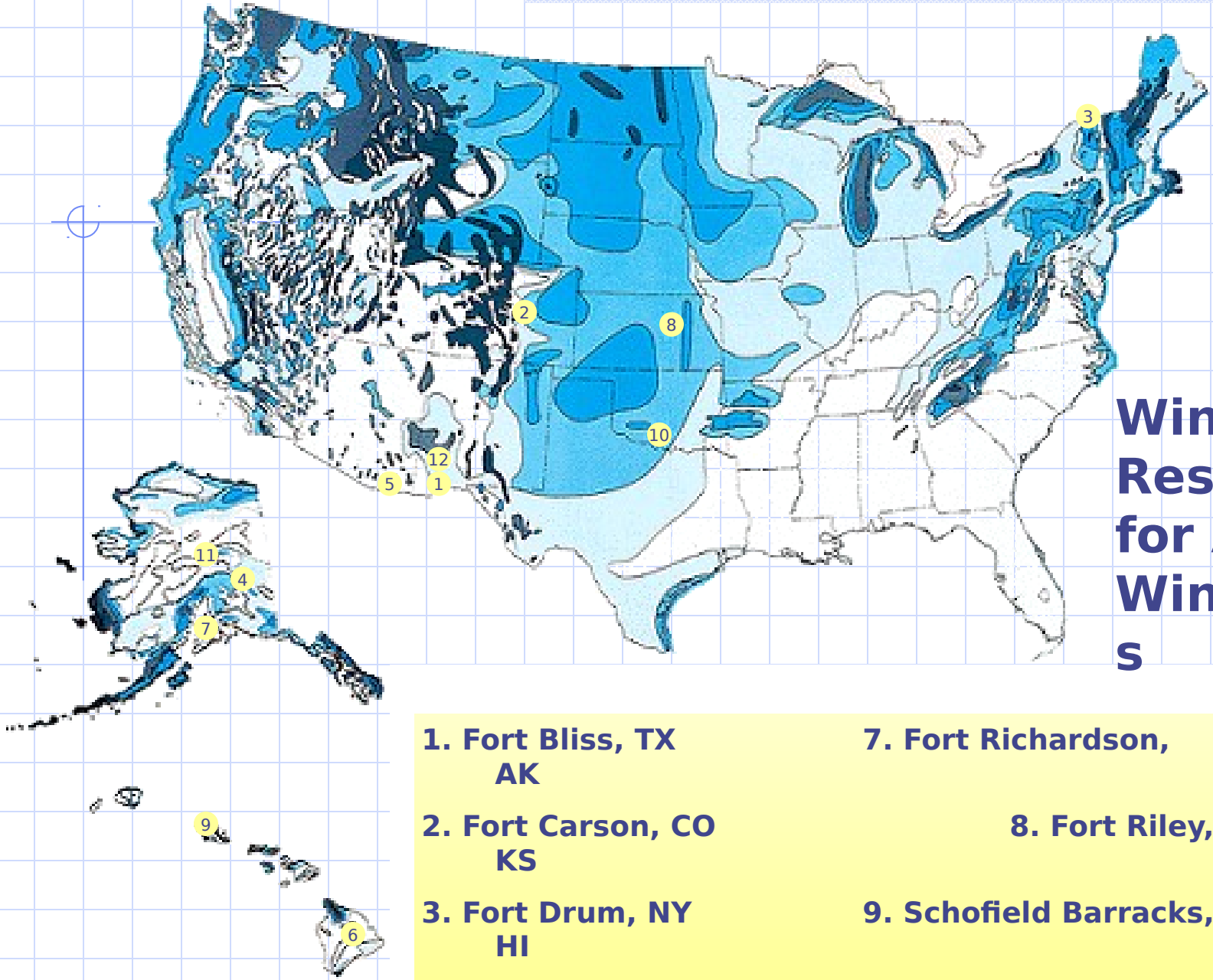
Courtesy NREL

DOE initiatives: 5% of the nation's electricity by 2020, increase states with > 20 MW to 16 by 2005 and 24 by 2010, increase federal use 5% by 2010.

Fastest growing electricity source in1990s.

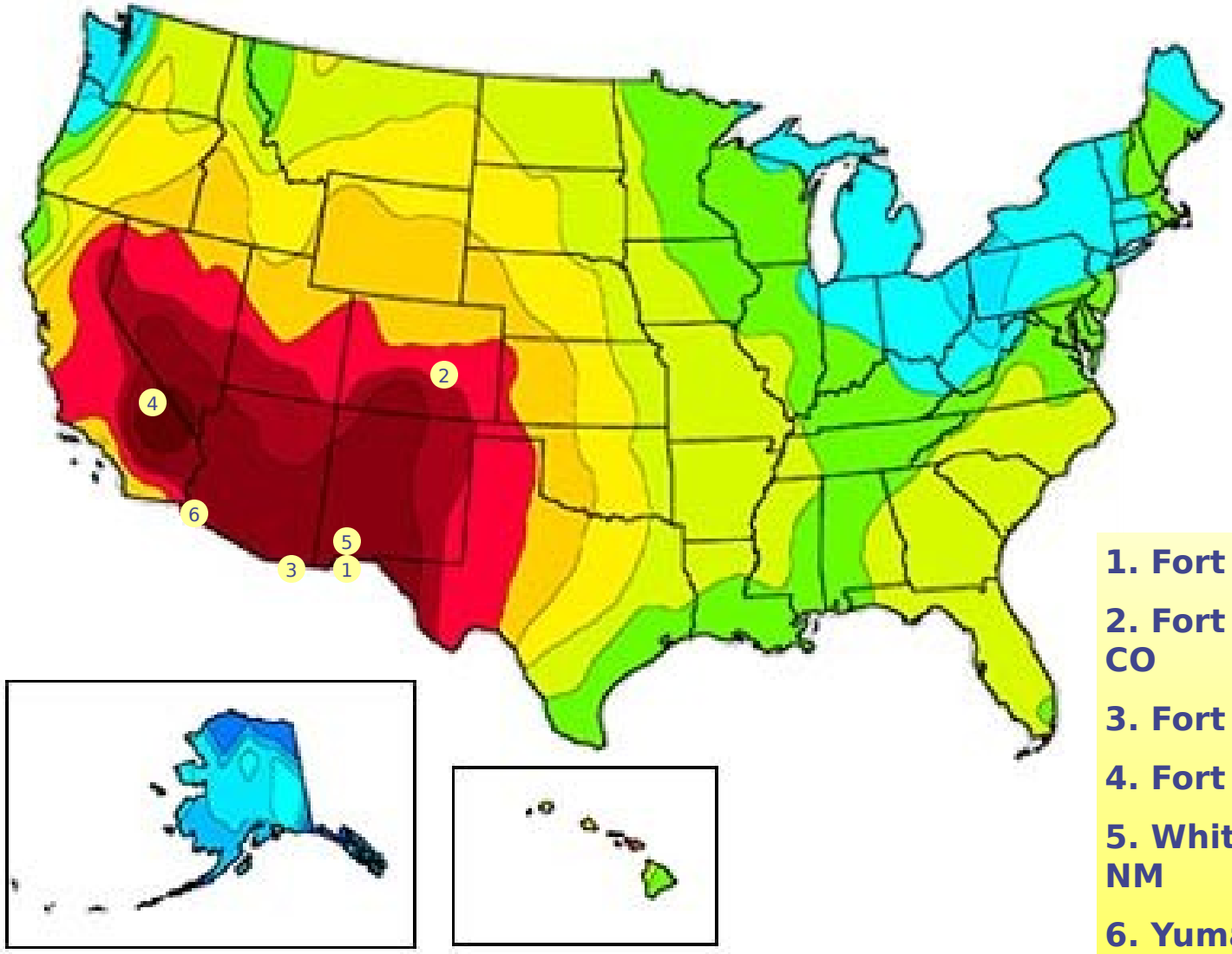
Wind Power Resources


United States - Wind Resource Map
Source: "Wind Energy Resource Atlas of the United States", 1987
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m²
Wind Speed* at 50 m m/s
Wind Speed* at 50 m mph
1 Poor 0 - 200 0.0 - 5.4 0.0 - 12.1
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb 800 - 1600 8.8 - 11.1 19.7 - 24.8
*Wind speeds are based on a Weibull k value of 2.0
U.S. Department of Energy
National Renewable Energy Laboratory
NREL



Wind Resource for Army Windfarms

1. Fort Bliss, TX
2. Fort Carson, CO
3. Fort Drum, NY
4. Fort Greely, AK
7. Fort Richardson, AK
8. Fort Riley, KS
9. Schofield Barracks, HI
10. Fort Sill, OK



1. Fort Bliss, TX
2. Fort Fort Carson, CO
3. Fort Huachuca, AZ
4. Fort Irwin, CA
5. White Sands M.R., NM
6. Yuma P.G., AZ

Solar Resource for Power Plant Applications

Energy and Atmosphere
Credit 3 – Additional Commissioning

INTENT:

- Verify and ensure that the entire building is designed, constructed, and calibrated to operate as intended.

REQUIREMENT:

- In addition to the Fundamental Building Commissioning prerequisite, implement the following additional commissioning tasks:
  - 1. Conduct a focused review of the design prior to the construction documents phase.
  - 2. Conduct a focused review of the construction documents when close to completion.
  - 3. Conduct a selective review of contractor submittals of commissioned equipment.
  - 4. Develop a system and energy management manual.
  - 5. Have a contract in place for a near-warranty end or post occupancy review.
  - Items 1,2, and 3 must be performed by someone other than the designer.

Energy and Atmosphere
Credit 3 – Additional Commissioning

TECHNOLOGIES/STRATEGIES:

- Introduce standards and strategies into the design process early, and then carry through selected measures by clearly stating target requirements in the construction documents.
- Tie contractor final payments to documented system performance. Refer to the LEED Reference Guide for detailed descriptions of required elements and references to additional guidelines.

Energy and Atmosphere
Credit 4 – Ozone Depletion

INTENT:

- Reduce ozone depletion and support early compliance with the Montreal Protocol.

REQUIREMENT:

- Install base building level HVAC and refrigeration equipment and fire suppression systems that do not contain HCFC's or Halon (1 point).

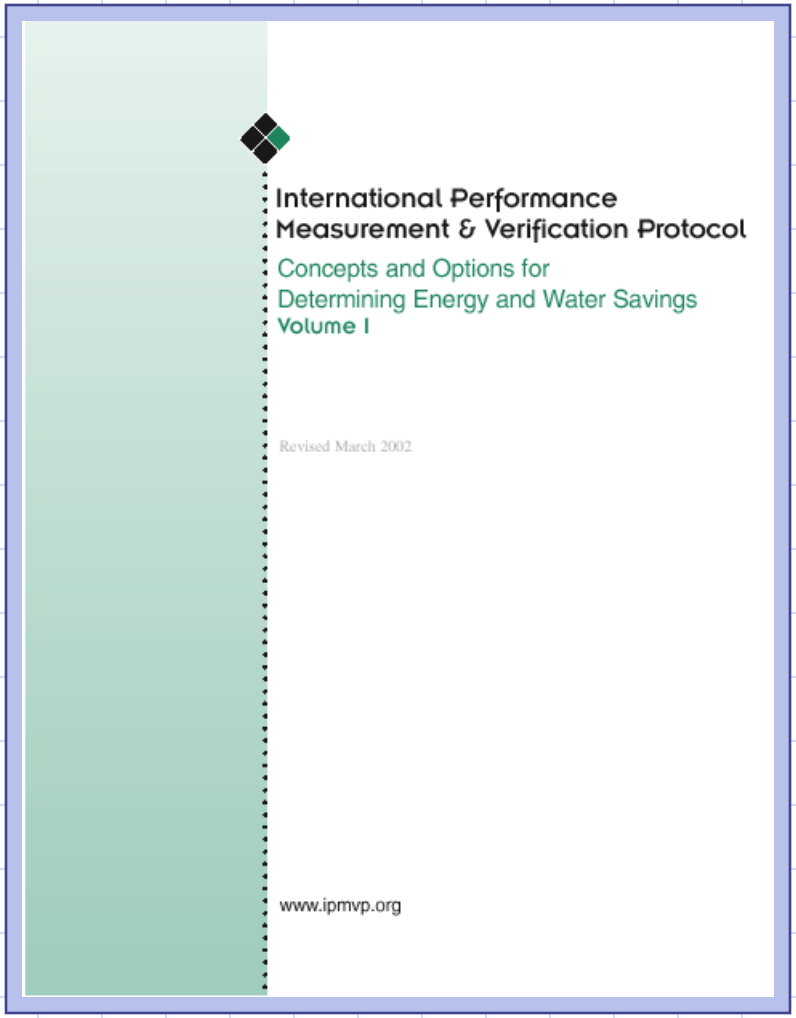
TECHNOLOGIES/STRATEGIES:

- Utilize base building refrigeration and fire suppression systems that use no HCFCs or halons. Refer to the LEED Reference Guide for qualifying alternatives.

Energy and Atmosphere
Credit 5 – Measurement and Verification

INTENT:

Provide for the ongoing accountability and optimization of building energy and water consumption performance over time.



Energy and Atmosphere
Credit 5 – Measurement and Verification

REQUIREMENT:

Install continuous metering equipment for the following end-uses:

- Lighting systems and controls
- Constant and variable motor loads
- Variable frequency drive (VFD) operation
- Chiller efficiency at variable loads (kW/ton)
- Cooling load
- Air and water economizer and heat recovery cycles
- Air distribution static pressures and ventilation air volumes
- Boiler efficiencies
- Building-related process energy systems and equipment
- Indoor water risers and outdoor irrigation systems

Develop a Measurement and Verification plan that incorporates the monitoring information from the above end-uses and is consistent with Option B, C or D of the 2001 *International Performance Measurement & Verification Protocol (IPMVP) Volume I: Concepts and Options for Determining Energy and Water Savings*. (1 Point)

Energy and Atmosphere
Credit 5 – Measurement and Verification

TECHNOLOGIES/STRATEGIES:

Model the energy and water systems to predict savings. Design the building with equipment to measure energy and water performance. Draft a Measurement & Verification Plan to apply during building operation that compares predicted savings to those actually achieved in the field.

Energy and Atmosphere
Credit 5 – Measurement and Verification

M&V Option	How Savings Are Calculated	Typical Applications
B. Retrofit Isolation Savings are determined by field measurement of the energy use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Engineering calculations using short term or continuous measurements	Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor. In the baseyear this meter is in place for a week to verify constant loading. The meter is in place throughout the post-retrofit period to track variations in energy use.
C. Whole Facility Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.	Multifaceted energy management program affecting many systems in a building. Energy use is measured by the gas and electric utility meters for a twelve month baseyear period and throughout the post-retrofit period.
D. Calibrated Simulation Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end-use metering.	Multifaceted energy management program affecting many systems in a building but where no baseyear data are available. Post-retrofit period energy use is measured by the gas and electric utility meters. Baseyear energy use is determined by simulation using a model calibrated by the post-retrofit period utility data.

Energy and Atmosphere
Credit 6 – Green Power

INTENT:

- Encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.

REQUIREMENT:

- Engage in a two year contract to purchase the amount of power equal to the projected building consumption generated from renewable sources that meet the Center for Resource Solutions (CRS) Green-E requirements (1 point).

Energy and Atmosphere
Credit 6 – Green Power

TECHNOLOGIES/STRATEGIES:

- Purchase power from a provider that guarantees a fraction of its delivered electric power is from net nonpolluting renewable technologies. Begin by contacting local utility companies. If the project is in an open market state, investigate Green Power and Power Marketers licensed to provide power in that state. Grid power that qualifies for this credit originates from solar, wind, geothermal, biomass, or low-impact hydro sources. Low-impact hydro shall comply with the Low Impact Hydropower Certification Program.

Energy and Atmosphere
Credit 7 – Distributed Generation

INTENT:

Encourage the development and use of distributed generation technologies, which are less polluting than grid-source energy.

REQUIREMENT:

Reduce total energy usage and emissions by considering source energy implications and local cogeneration and direct energy conversion. Generate at least 50% of the building's projected annual consumption by on-site distributed generation sources (1 point).

Energy and Atmosphere
Credit 7 – Distributed Generation

- Technologies/Strategies:
  - Investigate the use of integrated generation and delivery systems, such as co-generation, fuel cells, micro-turbines and off-peak thermal storage.

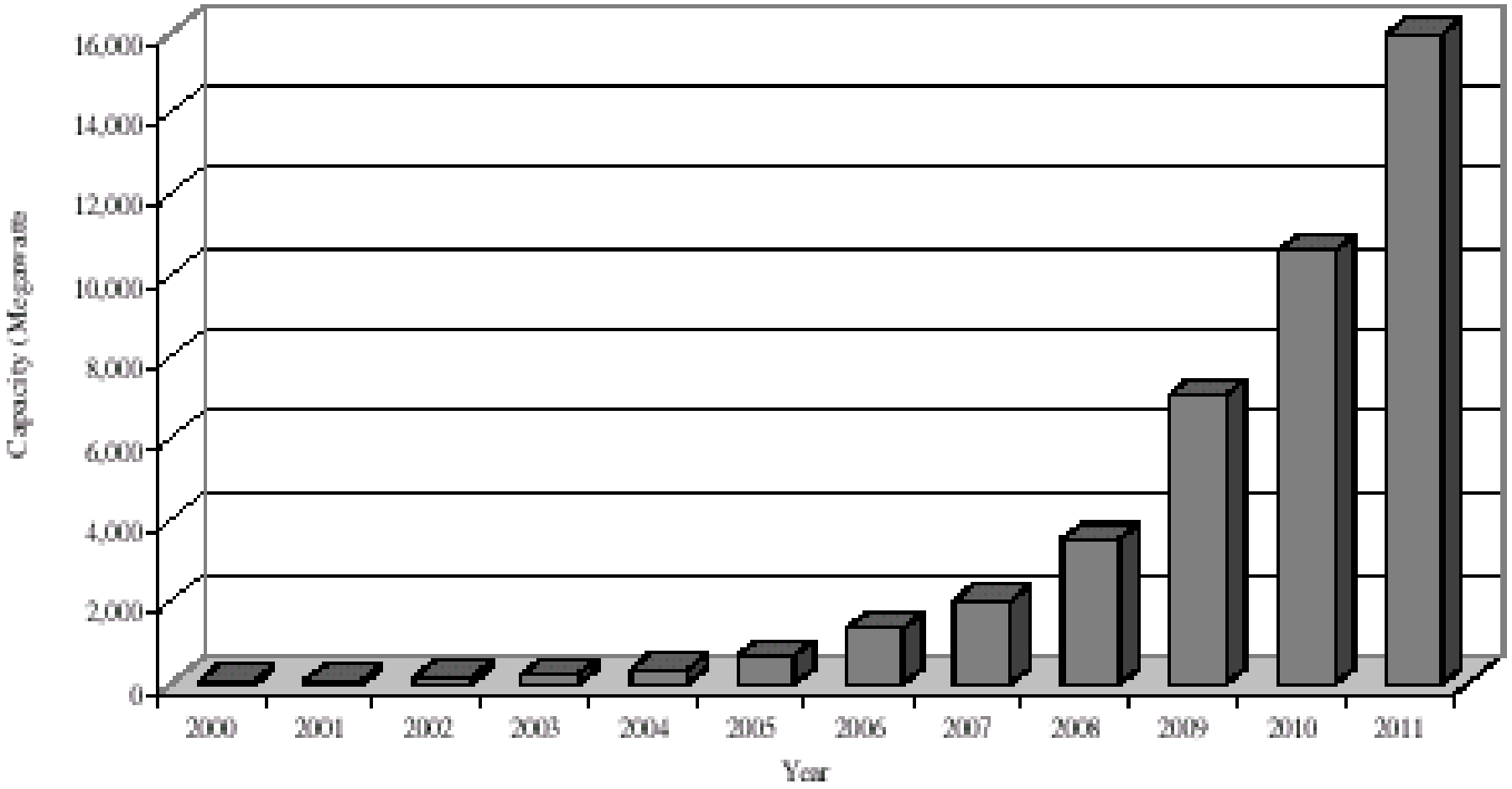
Fuel Cell Technology

- Poised for rapid growth, market is broad
- Technology will develop independent of government R&D support
- Transition technology to hydrogen economy
  Technology will vary based on size and usage
  - PEMFC
  - SOFC
  - MCFC

Nuvera

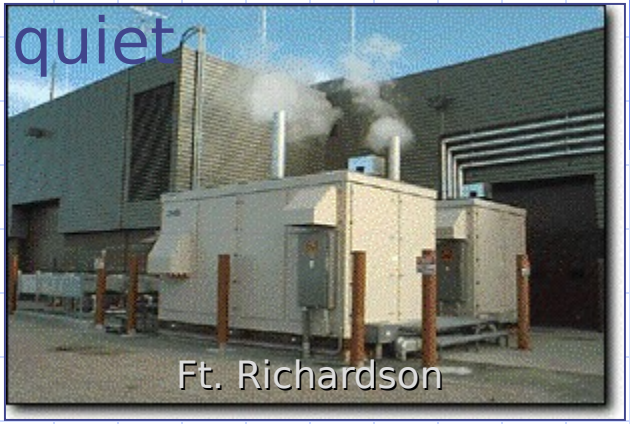
GE Homegen 7000

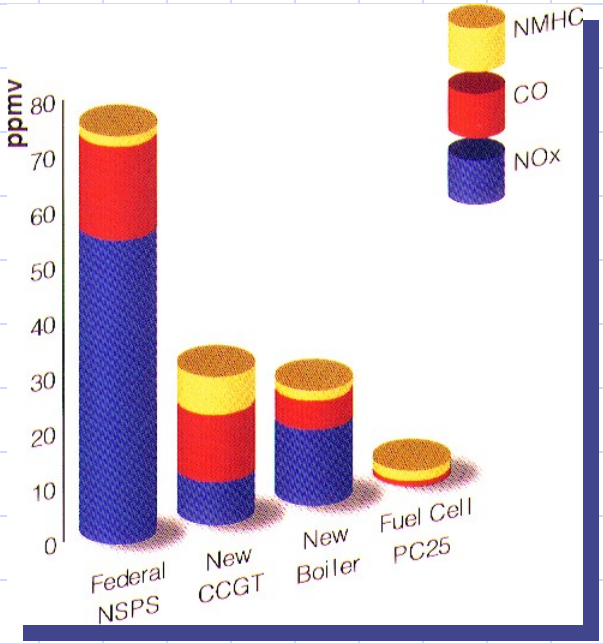
Fuel Cell Cumulative Electricity Generation Capacity,
World Market: 2000 to 2011
(Source: Allied Business Intelligence Inc)

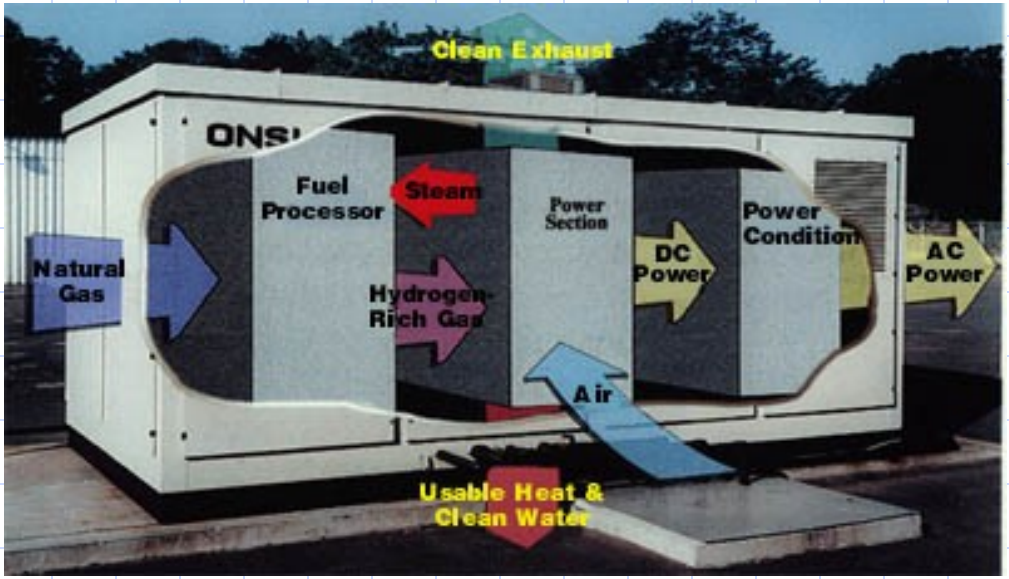


Fuel Cells for Combined Heat & Power

- $3,000/kW “Zero” air emissions, quiet
- 45% electrical efficiency
  Up to 90% overall efficiency
- Cost still high:





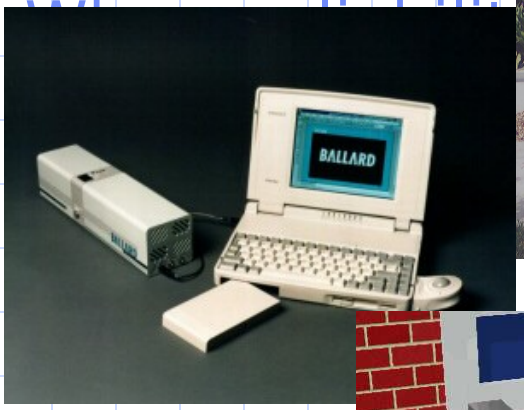


Fuel Cell Applications

- Central Heating Plants
- Hospital
- Utility Plants
- Pools / Gymnasiums

The Future of Fuel Cells

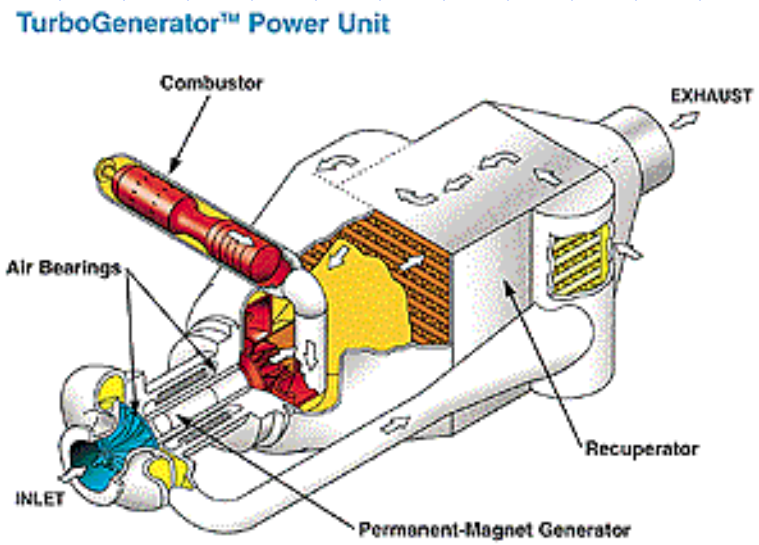
- Must get cost down to $1,500 - $2,000/kW
- Competes with $0.12 - $0.16/kWh
- Niche markets where air pollution is problem



- Other fuel cell technolog
  - Proton exchange membrane
  - Molten carbonate
  - Solid oxide
  - Alkaline

Micro-Turbines

- Size: 25 - 250 kW, only one moving part
- Small business losses: $7,500/yr for outa
- 75 kW: 30 SF foot print, 4000 lbs, ~$40K
- 30% electric eff., 65% - 75% w/heat reco
- 65 dB at 30 ft, 9 - 25 PPM NOx
- Expect >10,000 units in ‘0



Natural Gas Cooling Technology

- Engine Driven Systems
- Absorption Systems
- Desiccant Systems
- Benefits: Demand savings

NG Cooling Application

- Adequate engine cooling ventilation
- Adequate combustion air supply
- Cooling tower capacity for waste heat
- Proper commissioning is critical
- Increased maintenance
- Environmental permittir
- Exhaust location/design
- Noise attenuation
- Controls integration

Energy Resources

- CREST http://solstice.crest.org/sustainable/index.html
- DOE http://www.sustainable.doe.gov
- http://www.eren.doe.gov
- Environmental Building News http://www.ebuild.com
- Rocky Mountain Institute http://www.rmi.org
- Corps of Engineers http://www.cecer.army.mil
- The Home Energy Saver http://hes.lbl.gov/HES/
- Renewable Energy http://www.nrel.gov/
- Energy 10 http://www.sbicouncil.org/enTen
- EPA http//www.energystar.gov
- Moist 3.0 http://www.bfrl.nist.gov/863/moist.html
- Daylighting http://www.lbl.gov
- Green-E http://www.green-e.org